Innervation of the hard palate of the rat

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CHAPTER 10

SUMMARY

This study is undertaken to gain more insight into the pattern of innervation of the hard palate of the rat and into the morphology of the sensory structures found there. Since the main research project of the Department of Neurobiology and Oral Physiology is dedicated to the formulation of a model of the chewing system of the rat, the Wistar rat is choosen as an experimental animal. A total number of 113 adult rats, and 61 rat embryos is studied histologically and electron microscopically.

The first chapter deals with general aspects of the anatomy of the palate of the rat and the theories concerning its embryological development.

The specific aims of this study are given in the second chapter. The various methods used in this research are described in chapter three.

In addition, in chapter four, a modification of an in toto staining technique for nervous tissues according to Sihler (1895, 1900) is described. This modification is developed in order to investigate the gross innervation of the palate. On the basis of this modified technique preparations are obtained with a deep field of observation so that the relationship between peripheral nerves and surrounding structures is readily seen. In this way it is shown that:

1. The antemolar area of the hard palate is innervated by a fine diffuse network.
2. In the intermolar region of the hard palate most of the terminal branches end within papillae which are on top of the intermolar rugae. The lateral part of the intermolar region is more densly innervated than the medial part.

A diagram of the course of the various palatal nerves is presented.

In chapter five, the innervation of the ante- and intermolar rugae of the hard palate is described at the level of light and transmission electron microscopy.

Microreconstructions of the pattern of innervation of an antemolar and an intermolar ruga show that:

1. The antemolar ruga is innervated by a symmetrical fine diffuse network which is composed of a nervous plexus (sprouting from the nervus palatinus anterior) and nerve bundles which run caudally and rostrally through the connective tissue core of the ruga towards the epithelium.
2. The pattern of innervation of an intermolar ruga is asymmetrical. This type of ruga is innervated by a nerve bundle that runs, at the rostral side of the ruga, from the base of its connective tissue core towards its tip.

Three types of nerve fibres are found in the intermolar rugal papillae. The frequency of occurence of these three types of fibres appears to be different in the various parts of the papillae.
In the basal region of a papilla fibre bundles composed of myelinated and unmyelinated nerve fibres are found. These bundles split up in the intermediate region into solitary myelinated and unmyelinated fibres. In the top region of the papilla, only unmyelinated fibres are found. These fibres take the form of either lanceolate or free nerve endings which are in contact with the basal lamina of the epithelium; occasionally both types of endings are found intra-epithelially.

The distribution of the three types of fibres in the various part of the papillae suggests that:

1. lanceolate endings originate from the myelinated fibres in the intermediate region, which in their turn are continuations of the myelinated fibres of the basal region;
2. free nerve endings are related to the unmyelinated fibres in the basal and intermediate region.

In chapter six, the morphological characteristics of Merkel cell-neurite complexes are described. These complexes, catagorized as type I slowly-adapting mechanoreceptors by Iggo and Muir (1969) and Pubols and Munger (1971), are found in the basal layer of the epithelium of the rugae of the entire hard palate. The Merkel cell is in close contact with a nerve terminal which contains numerous mitochondria and clear-cored vesicles. Asymmetric membrane densities are observed between a Merkel cell and its neurite or adjacent keratinocytes. The cytoplasm of a Merkel cell is characterized by an accumulation of membrane bound dense granules at the neurite side of the cell, and by a well developed Golgi apparatus at its keratinocyte side.

In chapter seven, the ultrastructure of the intra-epithelial nervous structures of the palatal rugae is described. Lanceolate nerve endings (which are either rapidly or slowly adapting mechanoreceptors) and free nerve endings (which are thought to be receptors for pain, heat and force) are found between the basal lamina of the epithelium and the base of the epithelial cells, or, suprabasally, in the intercellular spaces of the epithelium.
In lanceolate endings, asymmetric membrane densities are seen between the neurite and its Schwann cell. In these structures the Schwann cell shows signs of pinocytotic activity at all sides of its plasma membrane. The basal lamina of the Schwann cell covering of the nerve endings appeares to be continuous with the basal lamina of the epithelium.
Cytoplasmic processes of epithelial cells invaginate the Schwann cells of the free nerve endings. Junction between, or fusion of the cell membranes of the epithelial cells and the Schwann cells are never found. The intraepithelial neurites are characterized by numerous mitochondria, clear-cored vesicles and an axoplasmic reticulum. The observation of Cauna (1959) and Munger (1965) that nerve fibres course through the epidermis independently of the intercellular spaces apparently penetrating the epidermal cells, is not confirmed in this study. In contrast, the intra-epithelial sensory structures are exclusively located within the intercellular spaces, their neurites being always invested by Schwann cells.

In chapter eight, the morphology and the frequency of distribution of taste bud-like corpuscular receptors in the palate is described. The material studied extends from the day of birth through 180 days after birth. The corpuscles appear as round (diameter 35-50 µm) to ovoid (width 40-60 µm, height 60-90 µm) bodies nestling among the epithelial cells of the incisal papilla and the soft palate. A subepithelial nerve plexus surrounds the base of a corpuscle. Four types of cells are identified at the electronmicroscopical level within the corpuscle: 1). basal cells, 2). Type I (dark) cells, 3). Type II (pale) cells and 4). Type III cells which had synapses. Some cells bear microvilli which protrude through a pore into the oral cavity. Numerous nerve endings terminate in close relation to the latter three types of cells. Two distinct types of membrane specializations are found representing axo-somatic and axo-axonal contacts. On morphological grounds, the structures described are interpreted as receptors of taste.
At birth, a total of about 20 corpuscles is counted in the entire palate of which 30% is found in the incisal papilla and 70% in the soft palate. During the first two weeks of postnatal life the number of

corpuscles increases to about 80 (distribution: 60% in the incisal papilla and 40% in the soft palate). Thereafter, a significant decrease in corpuscle number occurs with increasing age. We speculate that this shift in distribution of corpuscles is associated with a learning process of food selection.

In chapter nine the central projections of the afferent fibres of the entire palate and the source of innervation of the corpuscular receptors in the palate is described. The central projections were made visible by transganglionic transport of horseradish peroxidase conjugated to wheat germ agglutinin (WGA-HRP) and by Substance P (SP) immuno-histochemistry. WGA-HRP injected into the incisal papilla is taken up by the nerve fibres that terminate in the corpuscles. Retrogradely labeled neurons are observed in the trigeminal ganglion; anterogradely labeled terminals are found in the dorsolateral part of the spinal trigeminal nucleus and in the lateral part of the nucleus of the solitary tract. No labeling is found in the geniculate ganglion, the facial nerve and the hypoglossal nucleus. A WGA-HRP injection into the intermolar area or in the soft palate, causes only labeling of the trigeminal ganglion cells. The lamina propia of the entire palate, and the corpuscles enriched area of the incisal papilla and of the soft palate, are richly innervated by SP-containing fibres. Numerous SP-containing fibres are also observed in the nerve plexus at the base of the corpuscles. In addition, SP-positive neurons are identified in the trigeminal ganglion, whereas SP-labeled terminals are found in the sensory trigeminal nuclear complex and in the solitary tract nucleus. On the basis of these morphological observations, it is concluded that the palatal corpuscular receptors are involved in taste perception which is of trigeminal origin.

CONCLUSIONS

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